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ANALYZING THE FEEDBACK LOOPS OF THE FIRM'S FINANCIAL SUBSYSTEM

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Analyzing the feedback loops of the firm's financial subsystem

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1.- Introduction

In this paper we intend to study the variables that make up the firm's financial subsystem and their interrelationships. The objectives we pursue are basically two: 1º) To analyze and to understand the mechanisms of controling and shaping the firm's financial subsystem, and 2º) To search the effect that an action on a specific variable cause in whatever variable of the subsystem.

Due to the use of System Dynamics methodology[1] in a certain form, to help us in the achievement of our objective; it should be necessary to point out some basic concepts previously. The kind of explanatory relation of the system dynamics behaviour, whatever the system, is called *feedback loop* that appears when a variable is affected by the action that was provoked by itself. It will be necessary to define when the feedback has a positive or negative sign.

A feedback loop will be positive when the provoked effect has the same sign that the cause that origined it. For example, in the figure 1A, a loop of this kind is shown. If the capital in the bank grows, the same will occur to its interest added each period, and again the capital will grow further, and so on. This kind of loop yields growing, or decreasing, processes in the system.

In the other hand, when the effect has the opposite direction that the cause that origined it, it is said, that is a negative feedback loop. This kind of loops search the attainment of a certain goal (they are a goal-seeking) therefore they are a control mechanism in the system. In the figure 1B, if target inventory is increased, inventory order rate will initially rise, causing actual inventory to climb; but as actual inventory moves closer to target inventory, the order rate falls back toward its starting point.

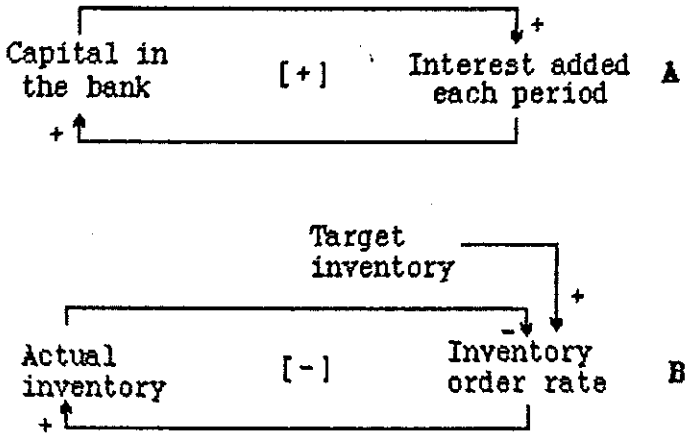

Fig. 1.- Positive and negative feedback loops

The kind of graphic shown in the figure 1 is called *causal diagram*, which reflects the effect caused by the actions encouraged by some variables on each others. For this reason, the variable-cause is placed on the tail of the arrow, and the sign representative of the effect produced on the variable-effect will appear on the head of the arrow. If the sign is positive (+) the effect has the same direction as the cause that origined it , while if it is negative (-) it will have the opposite direction. When a feedback loop has an odd number of negative signs it is said its feedback is negative (fig. 1B), but if it was even it will be positive.

2.- The firm's financial subsystem

As we know the basical objective of the firm is facing up an unsatisfied demand. To reach this goal, the company is obliged to carry out investments continously in fixed assets and in current assets, this requires a disponibility of financial resources, necessary. The firm will do those investments whenever their profitability goes beyond the cost of their financial resources, because otherwise the firm's survival will be seriously affected.

Figure 2 shows a causal diagram refers to the previous paragraph, which summarizes the firm's financial problem, that is, a schematic and intuitive representation of its financial subsystem.

Although along this paper we will develop in detail each one of the relations shown in that figure we can see already two importants loops to understand the dynamic behaviour of the subsystem that was commented previously. The first of them is in charge of the firm's growth, the mechanism is the following: If the demand grows it will be necessary increase investments in the firm's production capacity, this will produce a profitability that will increase the firm's growth and the same will occur with the demand, which as it is well served will aim to increase its orders and the previous cycle will be repeated.

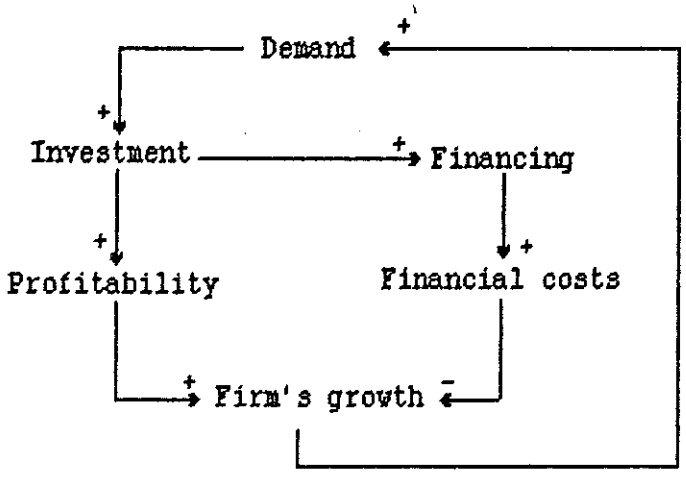

Fig.2. Causal diagram of the firm's financial subsystem

On the other way, if investments go up, financial resources must be increased too, necessarily. As a result, financial costs will turn in the same direction (growth) and it will damage the business growth; even more, the demand will tend to decrease (since if investments are unsufficients the production will not increase, and the unsatisfied share of the demand will shift to other companies). Notice that the variable called here "firm's growth" is in charge of comparing investments profitability with their cost.

The causal diagram shown in the figure 2 represents a much more complex system than the one studied previously; for this reason, here on we will begin studying all subsystems that make up the firm's financial system (here on, we will refer to financial system, not subsystem, because we are going to study it trough the system methodology).

3.- Relationship between demand and production

The first step in order to analyze the firm's financial system will be to study the relationship between demand and production in the company. Which is the cause of dynamic behaviour of the remaining of the system, as we already could see in the previous epigraph.

Apparently, the relationship between both variables is a positive feedback loop. Because it seems logic that if the demand goes up, the company's production increases in order to face that switch and, on the other hand, when the production volume grows up, it will be possible to serve the products faster and more efficiently (supposing "ceteris paribus"), resulting in a better welcoming of the customers that will result in a increase of demand.

We can certainly argue that as the demand is a exogenous variable to the system-firm, it is difficult enough for the latter to control it. Controling it is not possible, of course, but it may influence on the variable. As a matter of fact the marketing subsystem of the firm has as a main target to influence on the company's demand and one of the ways that the firm has to improve the customers' opinion about itself, is to deliver the products they had ordered as soon as possible; however, to achieve this, products must be previously produced.

The relationship between both variables takes place with the help of some intermediate variables that affect the positive feedback loop behaviour previously mentioned (see fig. 3). In the figure we can see a group of eight variables interrelated through four feedback loops, two positive and two negative.

When the demand goes up it will produce, logically, a increase in the order level by the market; this will yield an increase in the delivery volume. The degree of satisfaction is a ratio that shows that part of the orders has been delivered during the period, therefore its value will fluctuate, between zero and one; the closer to one, the bigger will be the market satisfaction; on the other hand, the closer to zero, the larger will be the unsatisfied customers, which will go to buy to the competition. So if the deliveries go up the degree of satisfaction will do the same, or won't decrease at least, it will increase (or keep up) the company's demand. This is a positive feedback loop, because at the beginning we suppose the demand began increasing and the loop has finished doing the same.

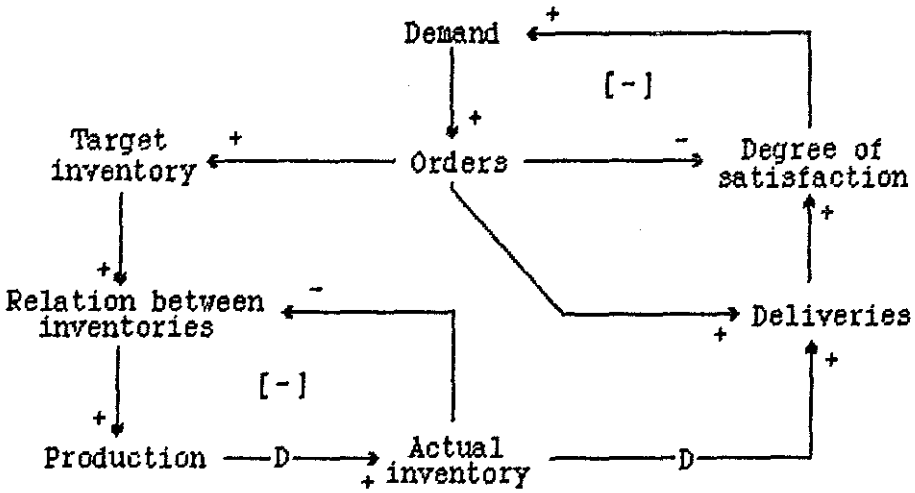

Fig.3. Causal diagram of the relationship between the demand and the production

The former loop is controled by another of negative sign which is in charge of limiting the growth effect of the other, that is, this loop controls the company's demand. In figure 3 it is possible to see that if we suppose the demand is growing the order volume will turn in the same way too, which will rebound negatively on the degree of satisfaction and on the market itself.

If we look at both loops we can see that the larger the number of products that can be delivered in a certain moment, the bigger will be the firm's positive influence on the market. However, to have a big amount of products in the warehouse would not be profitable due to the inventory costs volume (maintaining, opportunity, etc.). Therefore, if an increase in orders is produced the firm will incur the risk of not being able to deliver all of them, and the demand will tend to go down. Only a good management of the products inventory will enable the degree of satisfaction to be as close as possible to the unity, this way the firm's deliveries efficiency can be optimized.

The product inventory will depend on the units produced by the manufactoring system, this is why we will briefly analyze its functioning.

We can see in figure 3, that if the orders go up, because of an increase in the demand, the firm's management will have an idea of what the target inventory should be (this idea comes up in base of some forsight studies about the market's future behaviour, or the own intuition or experience of the managers). The ralationship between both kinds of inventories, target and actual, is the variable that increases or reduces the company's production level. Therefore, if the target inventory increases, the management will increase the production rate and the actual inventory grows up too. The deliveries depend on the orders as well as the actual inventory level of products, the smallest value of both variables will be the deliveries value, that is we can not serve more products of that we have in the actual stock, neither can we deliver more products that orders (in the first case, we don't sell products because our inventory is broken, and in the other case we will have some products in the stock, which involves a cost). If the actual inventory goes up, the number of the delivered products will tend to do the same which will affect positively the demand.

The variables mentioned before shape a positive feedback loop, which is controled by the other loop with opposite sign and it is made up by three variables: Production, actual inventory and the relationship between inventories. When the actual inventory goes up (because production increases too) the difference between the actual and target inventories will decrease and even, the former will be bigger than the latter sometimes. Summarizing, the goal pursued by this loop is to make equal the volume of both inventories, so it is a production control loop.

The bahaviour of the relationship between the demand and the production is explained by the interaction of the four previous loops. But we must not forget that every feedback loop has delays, as information or others flows within them. For example, the reader can observe easiliy, that the management decides an increase in production until it is attained, a gap of some days, weeks or, even, months appears, which has an important effect on the system's dynamics bhaviour. The two basicals delays in this subsystem are the *period of production* (it relates the production and actual inventory variables) and the *period of delivery* both of them are represented in figure 3 with a D letter.

4.- Relationship between production and investment in fixed asset

The production can be decreased if the demand requires so, it is even possible to discontinue production. However, the production can be increased until the production capacity is achieved. That is, if it is necessary to manufacture even more products, the firm should increase the

production capacity buying more machines, assembling some workshops, buying some buildings, etc., that is, investing in the fixed asset.

In figure 4, the relation between both variables of the financial system is shown. In it we can see three loops, two of them have a negative feedback while the third, the most important, has it positive.

The firm's management has in every moment an idea of what the target production capacity should be, depending on the production variations (these, in its turn, will depend of the demand variations, as we could see in the epigraph before), that is, if the production increases, the production capacity will tend to do the same, as it seems logical, and the opposite is also true[3]. If the management decides that the production capacity must grow, it will imply the necessity of investment in the firm's fixed assets, which will increase the installed production capacity, and will allow a further production growth. This loop is a positive feedback that drives to the growth of the firm's production capacity; now then, we should have in our mind that an important delay exists in that loop, from the moment that management decides to enlarge the capacity until this is done; the delay can be large some months sometimes and will affect the firm's future production behaviour. The management should have this in mind when it decides to increase the production capacity.

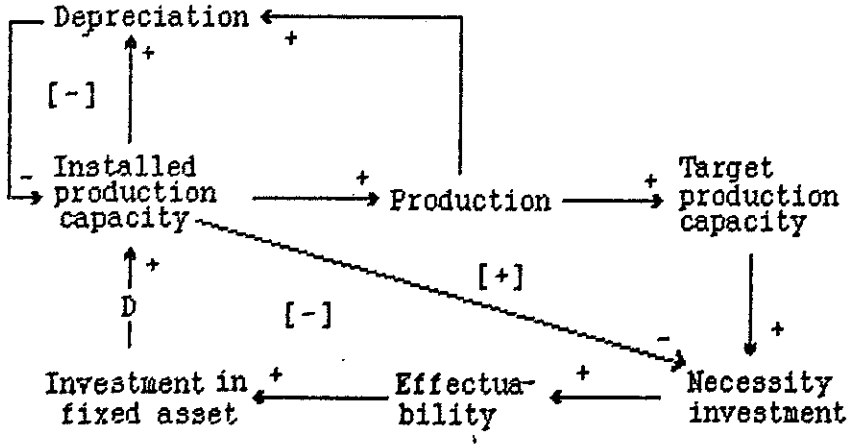

Fig.4. Relationship between production and investment in fixed asset

The necessity investment and the investment in fixed asset will depend basically on that the target production capacity is bigger than that set up (this condition is necessary, while the sufficient condition will be that its return is bigger than its costs - see next epigraph). So the relationship between investment and installed production capacity is a negative feedback loop because if the former increases the same will occur to the latter, and this will brake the investment growth.

On the other hand, the installed production capacity is subjected to a depreciation process which is negatively affected by it, through a negative feedback loop. This depreciation will depend on the own installed production capacity and on the production that was realized in the firm along the period.

5.- The investments effectuability

As we already commented before, the necessity of investing in the fixed asset depends basically on the increase of the demand. However, the decision to invest or not, rises from the comparison of expected return with its financing cost. The relationship between both variables will be discussed right away (see figure 5).

The principal block of the diagram, is represented by five variables that we have already studied previously: The investment in fixed asset, the installed production capacity, the production, the actual inventory and the deliveries. A delivery growth is produced when the investment in fixed asset has gone up (look out for the delays!), will increase the company's benefit.

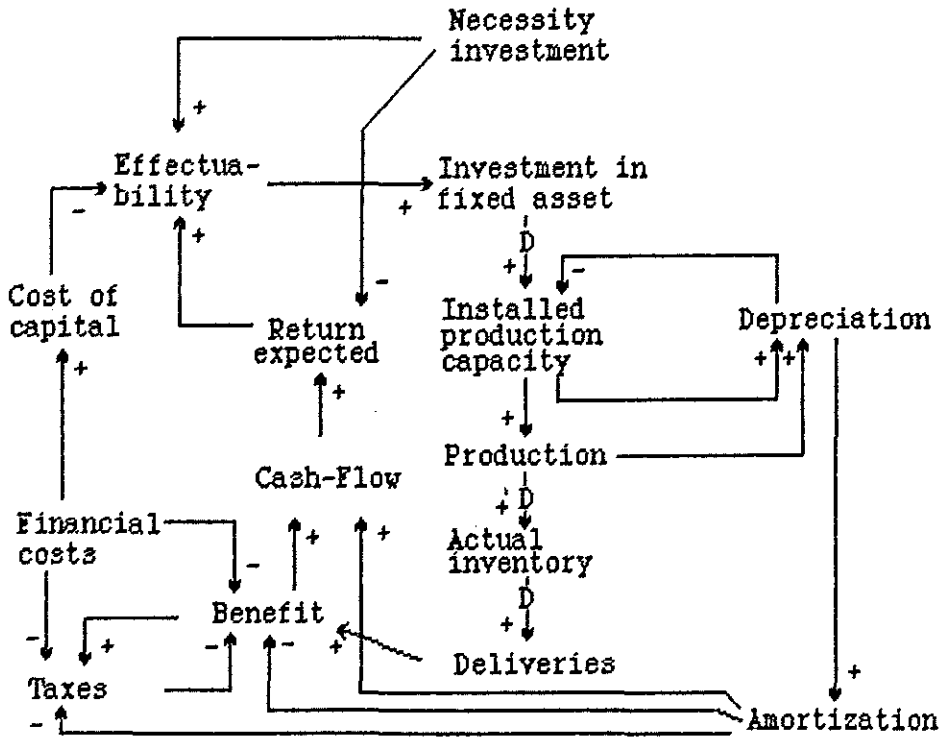

Fig.5.- Studying the investments effectuability

Now then, to carry out an investment, it is necessary that it is acceptable (return bigger than cost). For this reason, the investments should be subject to a valuation process, trying to know if it is effectuable

(acceptable) or not. Notice how both variables, necessity investment and effectuability, move together because of the existence of the second depends on the possibility of carrying out the first (for this reason there is a plus sign (+) between both variables is shown in figure 5).

As we already know, there is a set of investment evaluation methods that intend to help the manager to know if it is advisable to undertake a certain investment, or not. For example, the pay back, the net present value (NPV), the internal rate of return (IRR), etc[4]. Almost of these methods are baised on three main variables: the investment itself, its cash-flows and the cost of capital. To obtain the investment return we must use the cash-flows (the expected cash-flows can be obtained, generally, in base of the actual and past cash-flows - see fig.5) and the investment value (in figure 5 it is called "necessity investment"). The former increases the return while the latter tends to reduce it.

If we compare the expected return and the cost of capital of the investment we can infer if it is, or not, acceptable. If it were not acceptable, the investment in fixed asset would not exist, the production capacity will not increase and the demand, finally, will decrease (This is not bad necessarily, since the marginal increase of the firm's production capacity was not profitable for the company).

Before the cash-flows a certain period is obtained we must estimate the firm's benefit. The benefit is a direct function of the deliveries to customers and inverse of the financial costs, taxes and amortizations. The latter procedes from the installed production capacity depreciation. The financial cost depend on the liabilities volume and on their cost. The taxes depend on the benefit itself and it its turn they work on it negatively[5].

The conjunction between benefit and amortizations give us the cash-flow, that is, the difference between receipts and payments (not between income and expenses)[6]. It is possible to observe that the amortizations (that act on the benefit negatively) are added to the benefit to make up the cash-flow. Amortizations have been added and subtracted from the benefit, apparently its effect on the latter is null and void, and it would be true if the taxes did not exist. Summarizing, the benefit doesn't decrease because of the taxes as much as it should because the amortizations decrease taxes.

Summarizing, in the diagram shown in the figure 5 it is possible to observe a large positive feedback loop which tells us that the bigger the installed production capacity the bigger the deliveries and the same occurs with the cash-flow of the period. This will ease the effectuability of the possibles investments in fixed asset that must be done in the firm and that will make the production capacity increase. However, this loop can be studied in the opposite direction, that is, if a decrease is produced in the demand, it will have very much idle production capacity, which will imply

that there is no necessity of investing any more, it could even be possible that there exists a need to get rid of the idle part of the production capacity; this would reduce the level of production capacity.

6.- The firm's financial structure

In the previous epigraph, we have referred to the conditions that every investment in fixed asset must accomplish to be effectuable; the most important of them being, that the expected return goes beyond the cost of the financial resources employed in it. However, this resources may come from the firm or may be external and even in this case they can belong to the firm's owners (the shareholders) or to its creditors (bondholders, for example) all of them will demand a return for their contribution to the company's investments financing (dividends and interests) which will be their cost to the firm.

In figure 6, the causal diagram shows what we just have commented in the previous paragraph, which we are going to study with detail in the next.

We have seen (see figure 5) how the benefits are employed to obtain the cash-flow value[7] during a certain period (with the exceptions previously mentioned) and this, in its turn, makes the firm's funds go up. On the other hand, every investment in fixed assets implies another in current assets, and both of them need a set of financial resources for them to be carried out. Part of these financial resources can be supplied by the firm itself through its cash, and the other will come from the company's environment, that is, from debts. This will provoke an increase of the funds (for this reason, the loop has a negative feedback).

The increase of the firm's debts provokes a increase of their level, this produces two importants effects. On the one hand, it rises the financial costs level, which will rebound negatively on the benefit and, further, on the firm's avalaible financial resources which will tend to decrease forcing the issuance of new debt; this generates a positive feedback loop. On the other hand the increase of the debt level increases the leverage, which imply an increase of the debts unitary cost (if the financial risk is greater the cost will be too), this is going to worsen the company's financial situation. Note taht we are in front of a positive feedback loop reinforced, because it is superposed to the loop commented before; and it is the one which provokes that many firms are not able to stop the debt and financial cost increase which pushes them towards bankruptcy.

The firm's management will have a maximum leverage ratio desired beyond which they will tend to reduce the proportional amount of debt to total liabilities via an increase in common stock. This will increase the available financial resources and a further increase in debt to finance

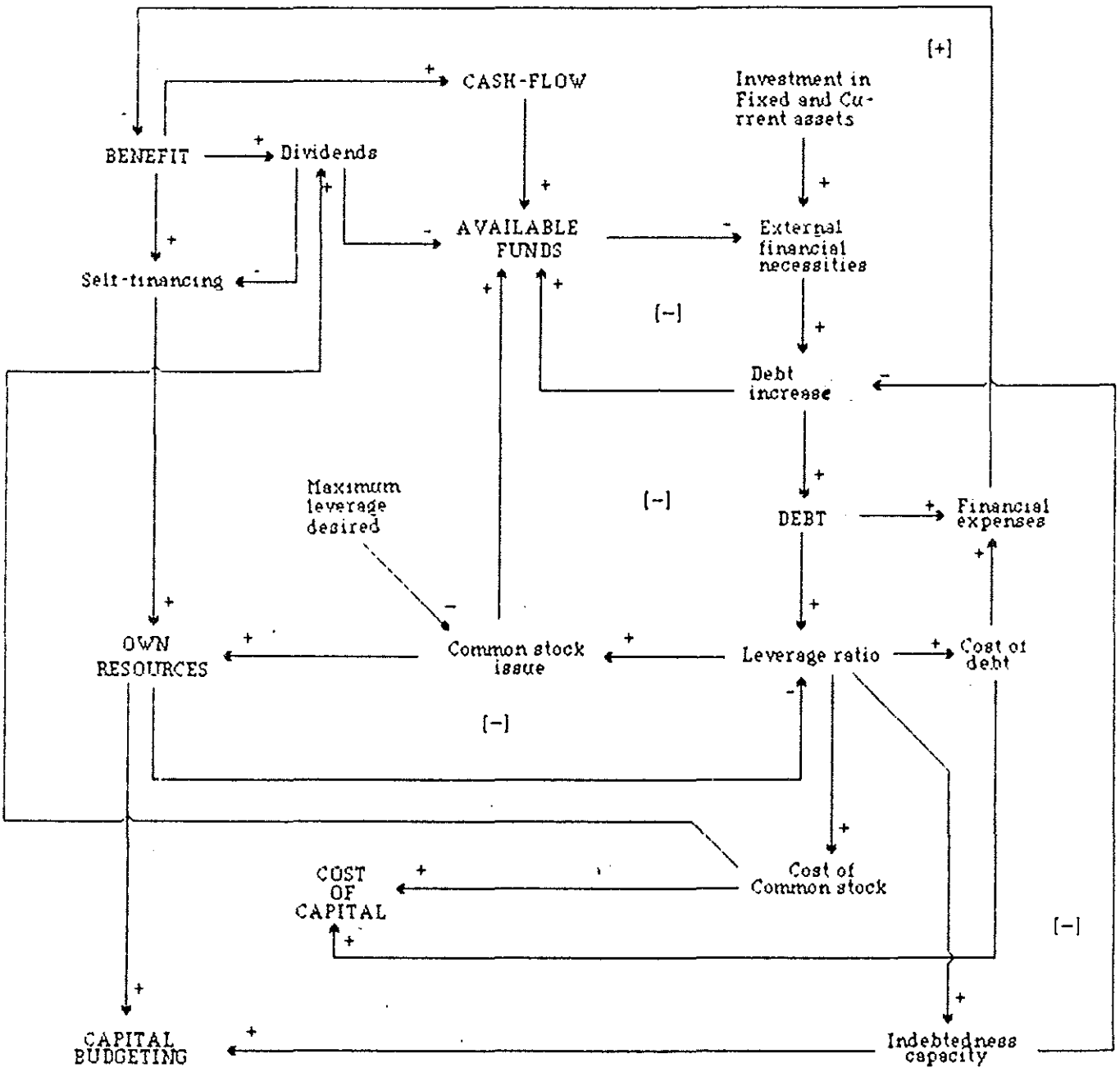

Fig. 6. The firm's financial structure

future investment could be no longer needed, which in turn could reduce debt and the leverage ratio. This negative feedback loop is in charge of controling the previous one because as the process of debt increase is reversed, the positive loop will work in favor of the firm enabling a reduction in financial expenses and marginal debt cost.

Common stock issue together with the period's self generated financial resources increase owner's equity which causes a decrease in the capital leverage ratio (negative feedback loop).

This ratio also influences the cost of the firm's own resources and its indebtedness capacity. With regard to its resources, an increase in the ratio will rise the financial risk which will increase the cost of equity to offset the adittional risk incurred by the stockholderss, this will yield a decrease of available resources accompanied by an rise in debt and the capital leverage ratio. This positive loop also represents a risk to the firm as if dividends are not increased, the market prices of the shares will fall, and could increase the difficulty for new placements with the undesired consequence the reader can imagine.

An increase in the ratio will reduce the firm's indebtedness capacity yielding a smaller increase in debt and slow down in the indebtedness. This negative feedback loop creates a oscilating movement in the indebtedness capacity and controls the possible increase in debt.

The capital budgeting value is obtained from the indebtedness capacity and its own resources. The capital budgeting represents the maximum financial resources that the firm can use in its total investments. On the other hand, the firm's cost of capital value (that is necessary to know if a investment is or not acceptable) is computed through the cost of equity and the cost of debt.

7.- Conclusions

Along this paper, we have tried to stand out the principal relations between the variables that make up the company's financial subsystem, searching to improve the understanding of its dynamic behaviour. For this reason, those relations have been grouped in feedback loops, which have been analyzed by us with detail, because they explain the dynamic behaviour of that subsystem.

It is important to have in mind that all variables which make up the financial subsystem, are related between them; this imply that an action over one of them will have repercussions on the others. For this reason, the manager must have in mind what will be the kind of influence of his possible actions on the principal variables of the financial area.

In this work we have not done any mention about the way to design the relations between the variables in mathematical form, which would allow us to build a model through it the manager could simulate his policy and study their effects on the subsystem variables. But this would extend the paper too much, and this phase of our study was not in our sight when it was written[8].

Notes

1.- For a further insight on this methodology we recommend the book by Forrester, J.: *Principles of Systems* Wright Allen Press, 1968.

2.- A more detailed study of the commercial system of the firm can be examined in: Forrester, J.: "Market Growth as Influenced by Capital Investment" in Roberts,E. (ed): *Managerial Applications of System Dynamics* MIT Press. 1981. And also in: Mascareñas,J.: "Estudio del comportamiento dinámico del subsistema comercial de la empresa". *Gestión científica* nº3. UNED. pp: 229 a 257

3.- An alternative way to calculate the target production capacity is via the study of the delay in the deliveries as it is done in the previously mentioned papers.

4.- On the investment project appraisal we recommend the book by: Suárez, A.S.: *Decisiones Optimas de Inversión y Financiación en la Empresa* Pirámide. Madrid. 1986 (8ªed.)

5.- If the reader is interested in financial planning models which calculates accounting states he can consult: Maroto,J. y Mascareñas,J.: "PLAFIN II: Un modelo de simulación para la planificación financiera empresarial". *Revista Española de Financiación y Contabilidad*, nº49. pages:223-255.

6.- In order to simplify we have assumed that the sum of benefits and amortizations is equal to the cash-flow, however this is so only if the receipts are equal to the income and the payments are equal to the expenses. An interesting discussion on this subject can be seen in: Suárez,A.S., in note 4. pages: 304-307.

7.- This way of modelling the cash-flow from the benefits is similar to the one used by H.Shehata in Coyle,R.G.: *Management System Dynamics* John Wiley & sons. Chichester. 1978, pages: 247-251

8.- On system dynamics models applied to different subsystems of the firm, see: Mascareñas, J.: *Propuesta y Análisis de Modelos de Empresa a través de la Metodología de la Dinámica de Sistemas* Universidad Complutense. Madrid. 1986.